cause luminosity (Fig. 4). It may be pertinent to cite Quatrefages' description of the luminosity of some marine animals.[1] I have observed that the light flashes in jets along the somites of these worms as if the segmental organs had something to do with its production and with the function of respiration. I have also shown that in the housefly the air-cells in the proboscis expand at each act of respiration.[2] It would thus appear that during inspiration the air is driven into the tracheal end-cells, as into the chambers of our own lungs, and that in this way the tissues are directly aërated. The slower process of aëration by the intervention of the blood may suffice in some larvæ, as in Crustacea, but the chief function of the blood of insects seems to be the conduction of food from the intestinal walls to the various organs.

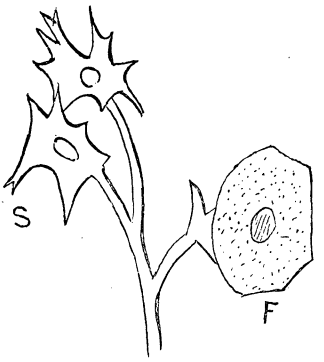

FIG. 4.—Stellate terminals (S) of tracheæ; F, luminous fat cells. After Schultze.

To sum up. The tracheæ of insects and similar organs are supported by chitinous fibers which are crenulations accompanied by thickening of the chitinous intima with which they remain continuous; their dorsal fissure and flexibility providing for the enlargement and reduction of the cavity; and the oxygenation of the tissues has its seat chiefly at the extremity of the tracheal branches, and not by diffusion from the tracheal trunks into the blood.

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AGRICULTURAL BOTANY.

BY E. LEWIS STURTEVANT, M.D.

THE secret of classification consists in the understanding of the motive, of which form and structure are exponents. The natural motive of plants is to secure existence and perpetuation, and parts and habits are and have been so formulated as to compass this object as against difficulties of very varied character. Each individual plant is in a state of unstable equilibrium, ever

[1] *Ann. d. Sci. Nat.*, Vol. XIX (1843).
[2] *Psyche*, No. 100 (Aug., 1882).

tending in the direction of least resistance, and so modifying its own nature as to become better fitted to meet such resistances as cannot be avoided. Each change is subject to transmissal through heredity, and thus through successive accretions, "Holding the gain and answering for the loss" plants become so differentiated as to react favorably with their environment, and in the course of time most numerous forms are established, each expressing the common motive in changes designed to meet a complex environment in which the various factors are of greater or less dominancy. The necessity for a constant struggle for perpetuation, as nature's law is, has made the reproductive organs paramount as expressing the method in which the plant-motive has been fulfilled, and hence the reproductive organs are dominant with the botanist for the purposes of classification, and the beautiful natural system of botany has become recognized as a science.

We have, however, a class of plants in which another motive than that of survival has become dominant, and in which the reproductive organs have become subservient, and this because under the protection and guidance of man, the necessity for the struggle for existence has been removed, and the plant has been left free to respond to new motives which have been impressed upon it. Our domesticated plants exist for man's service, not for their own, and accordingly such have developed away from nature's requirements towards man's requirements. The removing from a plant the necessity of warfare, and the substituting the conditions of peace and plenty, modifies such plant to some degree, but when in addition the motive is brought to harmonize with the desires of man by means of the process of selection, plants become profoundly modified in form and habit, and a parallelism of form is obtained which well illustrates the dominancy of the new motive. Thus the wild cabbage has furnished various divergent forms, and these forms in themselves resemble other forms which occur in plants of different species, genera and even natural orders. We have parallelism of form between varieties of the kale and parsley (dwarf curled kale and early cut-leaved parsley), the cabbage, lettuce, chicory, etc. (Tourlaville cabbage, cabbage-lettuce, scarole en cornet), the cabbage and the chard-beet (Pak-choi cabbage, white-leaf beet) according as the motive has been for leaf, head or stalk. This parallelism is to be seen in various others of our domesticated vegetables.

Just as the dominant motives in nature have secured fixity for types, so the dominant motives under art have secured fixity of type, but as the motives differ, so do the types differ. Hence natural botany cannot serve to secure classification for plants which have become domesticated, and for these latter we require a new botany, which we may call agricultural botany, and which must be devised alike in its principles with natural botany, but divergent in its methods of application in accordance with the divergent plant-motives.

In agricultural botany as in the natural botany, heredity must be considered in arrangement, for a true classification must deal with the totality of plant structure, form and motives, yet while in natural botany the reproductive organs, the expression of the paramount motive given to the plant by nature, must be considered paramount for the purposes of classification, in agricultural botany form must be considered as paramount as representing the paramount motive supplied to the plant by man. In the natural botany, species, genera, orders and classes represent stages in the development under nature, in the agricultural botany successive changes in selection represent stages in the life history of the new plant.

Premising that our remarks will be understood to apply to agricultural plants alone, we can illustrate our position by outlining a classification for roots.

When a wild plant is brought, through its seed, to the garden, and grown in rich soil and protected from weeds, the change in size of the root may be at once manifest, and the root may be smoother and less branching than in the plant under natural conditions, but the type of form of root remains the same even under many years of continued cultivation, unless modified by the process of selection. These protected, yet not domesticated roots, have this feature in common: the diameter of the root in its upper portion does not exceed the diameter at the stem and leaf insertion. Examples are the Scorzonera, salsify, Scolymus and horseradish. Fig. 1, Scolymus, and salsify, represents the type, of which salsify is at the farthest remove towards improvement. These plants become feral without change in the type of root.

Passing now to domesticated roots, we find two separate classes of selections with, in some measure, like selections within both. The first includes the tap-rooted forms, the second the caudate

forms. The parsnip is so little domesticated that its root-forms in general come within the first class, while the beet, carrot, turnip and radish present forms which can be referred to both classes.

Scolymus.

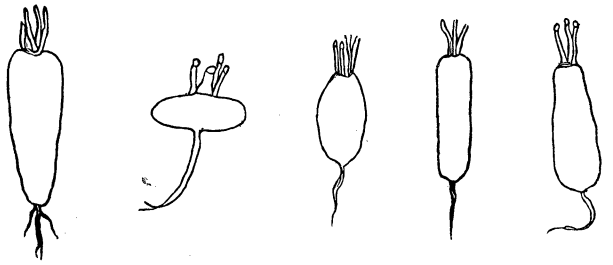
Salsify.

FIG. 1.

FIG. 2.

The first stage of the domesticated root is, that the upper portion of the root has a diameter in excess over that of the stem, and Fig. 2 represents the type of tap-rooted forms, in which the bulbous portion may be cone-form, cylindrical or almost globular, but in all cases the swollen portion tapers into the root.

The second stage of the domesticated root is the caudate, wherein, regardless of the form of the swollen portion, the root starts abruptly from a flattened surface, and gives a caudate appearance. The sub-stages within this stage represent the highest and most improved forms, and are represented in Fig. 3; *e*, or the tankard-



a *b* *c* *d* *e*

FIG. 3.

shaped, being the mark of extreme domestication, and each one of the types figured standing for the motive impressed upon the plant through conscious selection, and widely divergent from the forms which appear in nature as having no relations of advantage with and for the feral plant.

On account of the inter-relations of the two botanies, brought

about through the hereditary relationships of plants, the wild plant being the progenitor of the cultivated, it becomes essential to employ a symbol whereby agricultural relationship may be expressed without expressing conclusions as to botanical relationship as true species. A * placed after the generic name is what I propose. Thus *Tragopogon porrifolius* would be the scientific name for the salsify in Fig. 1; *Daucus * carota* for the cultivated carrots in all their forms, in order to distinguish them from the wild carrot, *D. carota*, etc., and ultimately a name for each stage or sub-stage of selection which has acquired fixity of type, as *D. * acuminatus*, the tap-rooted or stage 1 carrots, *D. acuminatus teretus*, the cylindrical tap-rooted carrot, etc., and within each of these agricultural forms, the varieties therein belonging to be grouped and described. It is thus seen that every type of cultivated plant-form which possesses constant characters under continuance of man's protection, and which differs from other type forms, would form an agricultural species; and that the same specific name would serve with the various genera of plants that have been forced to assume the same motive in development of form, as *Daucus * acuminatus teretus*, the cylindrical tap-rooted cultivated carrot, *Raphanus * acuminatus teretus*, the cylindrical tap-rooted cultivated radish, etc.

In the preliminary work in a new science much in the beginning must be provisional in its character, and hence we have selected for illustration a well-defined group of roots, leaving for later consideration the fascicled forms, as occur in the sweet potato and skirrit, as well as certain forms not as yet sufficiently studied. We but seek at this time a presentation of our views in order to invite discussion, and to secure coöperation, if our attempt is justifiable, from botanists whose studies include horticulture in its various branches; for if we are correct in our reasoning, the system, whose keystone is motive, must necessarily be applicable to all forms of changes produced by man's interference with nature. Of one thing we are assured through trial, that by using the motive given to the plant by man as furnishing data for classification, and by the study into the historical or probable sequences and stages of selection, we are enabled to form logical divisions and subdivisions in our garden forms, whereby identification of varieties by description has been furthered, and thus the study of domesticated plants in their economic relations has been rendered more easy for us to pursue.